Axel Böhme, Ellerau

Precision Viticulture

What Applications Are Conceivable?

If the soil, the climate, or the plant population within a vineyard differ significantly and if the area to be cultivated is sufficiently large, one should consider the application of computer-aided cultivation. Independent of the area size, precision viticulture provides the advantages of automation. This opens up possibilities for the procurement of information for documentation and decision making as well as for automatic machine control. Potential areas of application in viticulture are presented.

Dr. Axel R. Böhme was a doctoral student in the Department of Technology of the Research Institute for Viticulture in Geisenheim under the supervision of Prof. Dr.-Ing. Werner Rühling.
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Keywords

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Literature

Literature references can be called up under LT 03205 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

During demand-oriented fertilizing in crop cultivation, differences measured by nitrogen sensors are immediately utilized for treatment measures. As described by the words „measuring, calculating, and controlling in one work step", the green colouration and the density of the crops are measured using optical sensors, and the fertilizer quantity is adjusted according to the requirements [1]. Most computer-aided applications in viticulture which are ready for practical application are also based on such direct utilization of measured actual values.

Measuring, Calculating, and Controlling in One Work Step

For weed detection during herbicide application under the vine, two photo diodes equipped with different filters are installed near the spraying nozzle. They measure the specific light reflexions of weeds and soil. Only when weeds are detected is plant spray admitted to the nozzle through a solenoid valve. Initial studies showed high detection rates and, hence, 25 to 45% lower herbicide requirements while biological effectiveness diminished only slightly [2].

Plant protection using the Jacologic atomizer with detection of misses [3] is based on infrared sensors which measure the differences in reflexion intensity between a closed and a broken leaf wall in the target area of each single nozzle (*fig. 1*). If gaps in the plant row are detected near one nozzle, the spreading of plant spray is interrupted with the aid of solenoid valves. As compared with an identical atomizer without detection of misses, studies showed a 35% decrease in the plant spray requirements [4]. The detection of misses reduced drift and discharge onto the soil while biological efficiency stayed the same. The miss detection system increases the price of the atomizer by approximately € 5,000, i.e. almost 100%.

The company Pellenc equips their harvesters with a post protector. Photosensors („post sensors") detect the posts of the support equipment during the harvest. For protection, the shaking cycle is reduced in the post area [5].

Fig. 1: Atomizer with detection of misses (photo: Jacobi)

Collection of Basic Information

A comparison of yield distribution in the vineyard over several harvests provides important basic information. In Australia and in the USA, implements for yield measurement [6] have been offered since 1998 [7] and used in grape harvesters from the Gregoire company [8]. These systems determine the profile of the mash on the transport belt of the harvester with the aid of ultrasonic sensors. The yields are measured and mapped with the goal of detecting low-yielding areas in the vineyard and replanting them, if necessary. Experiences in the USA showed that measurement errors ranged between 5 and 10% [9]. Measurements in two Australian vineyards [10] have shown a noticeable area-related variation in the 1999 harvest yields. During the 2000 harvest, this variation largely repeated itself, which allows the conclusion to be drawn that it is location-related. On a field with vines of the variety Cabernet-Sauvignon and an average yield of 9

Fig. 2: Leaf cutter guided along a live trellis wire (photo: ERO)

t/ha, yields varied between less than 2 t/ha and more than 16 t/ha [11]. Systems for yield measurement (including the ultrasonic sensors, speed measurement on the transport belt, and the control unit) cost ~ US $ 10,000. Under Australian conditions, the estimated expenses given a five-year period of utilization amounted to A$ 3.8/t of harvested grapes.

Remote sensing with the aid of satellites or planes for the determination of soil conditions [12] and differences in vine development at the time of the harvest [13] is being tested. It is based on different reflexion by the leaf wall in the near infrared range, which is dependent upon the chlorophyll content. However, the problem of distinguishing between vines and soil cover has not yet been solved satisfactorily.

Automatic Implement- and Machine Control

The control of implements and the automatic steering of machines is a special form of variability management in the vineyard. For this purpose, mechanical, photo-optical, and electromagnetic sensors, as well as highly precise GPS systems can be employed.

Mechanical sensors for the automatic fine control of implements, for example, enable mulching work around the vine to be carried out under the plant [14]. If the sensor installed in front of the mulcher touches the vine, the mulcher is hydraulically swivelled out from under the vine. For the automatic control of the work platforms of cable mechanization systems, mechanical sensors are also being tested. The control of an automatically steered sprayer for use on steeply sloped fields (which is no longer offered) works without sensors and computers. In this implement, bars act directly upon the steering system when touching the vine.

In addition to mechanical systems, optical sensors can be used to control agricultural machines [15]. Control systems developed for combines would also be suitable for viticulture by allowing vine rows to be used for orientation. The combine sends bundled light impulses, which are reflected by the standing crops and the stubble. The light reflected by the stubble travels for a longer time than the light from the standing crops. The reflected light is received by the sensor, and the time difference is used to determine the crop edge along which the combine is steered. In vineyards, an electric field generated in a wire frame can also be used to control implements or machines. If an electric current flows through the wire of the support equipment, the machines can be guided along the magnetic field of this conductor [16, 17]. The wire can be supplied with electricity either via installed cables or the machine to be controlled itself through induction (like in the system developed by the company ERO) [18] (*fig. 2*). For this purpose, the wire must form a closed current circuit. This can be achieved by connecting two trellis wires, for example.

For the automatic control of vine planters, laser systems and, as of recently, also GPS are used. For the preparation of laser-based control, the vine rows must be marked at the upper and lower end before planting. The laser ray is then directed along the row, and the planter is guided along the laser ray. GPS-based control is simpler. Here, it is sufficient to determine a starting point for planting in the vineyard and to set the row direction. Guided by GPS, the machine then plants the first row in the given direction beginning at the starting point and uses it for orientation when planting all other rows.

While GPS-based parallel driving aids for earthbound vehicles are just beginning to establish themselves in crop cultivation, such systems are already widely used for the control of aircraft during plant protection treatment. These systems, which have become known as „flying flagman", would also make a decisive contribution towards better application quality during helicopter use in viticulture on steeply sloped fields. In addition, they would reduce costs and environmental impacts. Based on the working width of the aircraft, the system calculates the flight paths of the connecting swaths parallel to the first swath and guides the pilot accordingly. If the plant protection products run out over the field, the pilot is guided back to the point where the application was interrupted after refilling. In connection with a flow governor, differences in flight speed can be evened out in order to achieve an even application quantity. On the ground, flight recordings allow application quality to be assessed. The recorded data include flight paths, altitude, and application quantities.

A driverless, GPS-controlled viticultural tractor presented by John Deere at the end of 2001 as an experimental carrier provides further-reaching possibilities [19] (*fig. 3*). The automatic, GPS-controlled steering system for tracklaying tractors, which has been offered by John Deere since the end of 2002, initially only serves to facilitate the driver's work. It is not (yet) designed for automatic headland turns. When GPS-based automatic steering systems were tested in forage harvesters, deviations from the set path were below 100 mm [20].

Fig. 3: Driverless GPS-controlled viticultural tractor (photo: John Deere)